Appendix A: Annual Report-Fiscal Year 2008:

Monitoring Vegetation Composition, Structure, and Function in Crater Lake National Park: Results from a Pilot Study

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Abstract

This report describes the results of a pilot vegetation study undertaken in Crater Lake in 2008 to test the Klamath Network's Vegetation Monitoring Protocol. The pilot study found that the protocol could be implemented with an average rate of one plot sampled per day over the field season. Some minor changes to the protocol have been made as a result of testing the procedures during the pilot study. Data from the 17 plots that were sampled are summarized in a format that provides a template for future annual vegetation monitoring reports.

Introduction

In 2008 the Klamath Network tested its draft vegetation monitoring protocol at Crater Lake in a pilot study. The main objectives of the pilot study were to evaluate time and feasibility of the proposed sampling. Results are described here in the format the Network proposes to use in the future for annual reporting of the vegetation monitoring. Annual reports are intended for park staff and partners and will summarize the work completed in a given field season and the status of vegetation composition, structure and function based on the data collected.

Methods

Site Selection

As described in the vegetation protocol, the sampling frame that will be used in monitoring excludes areas with slopes greater than 30 degrees, and less than 100 m from a road or trail or farther than 1 km from a road or trail. There are three sampling domains: 1) Elevations above 2057 m (6750') (Alpine), 2) Areas within 20 m horizontally of a perennial stream (Riparian), 3) Remaining areas (Matrix) (Figure 1). We randomly selected 8 riparian, 15 matrix, and 12 alpine sites in a spatially balanced arrangement for sampling (Figure 1).

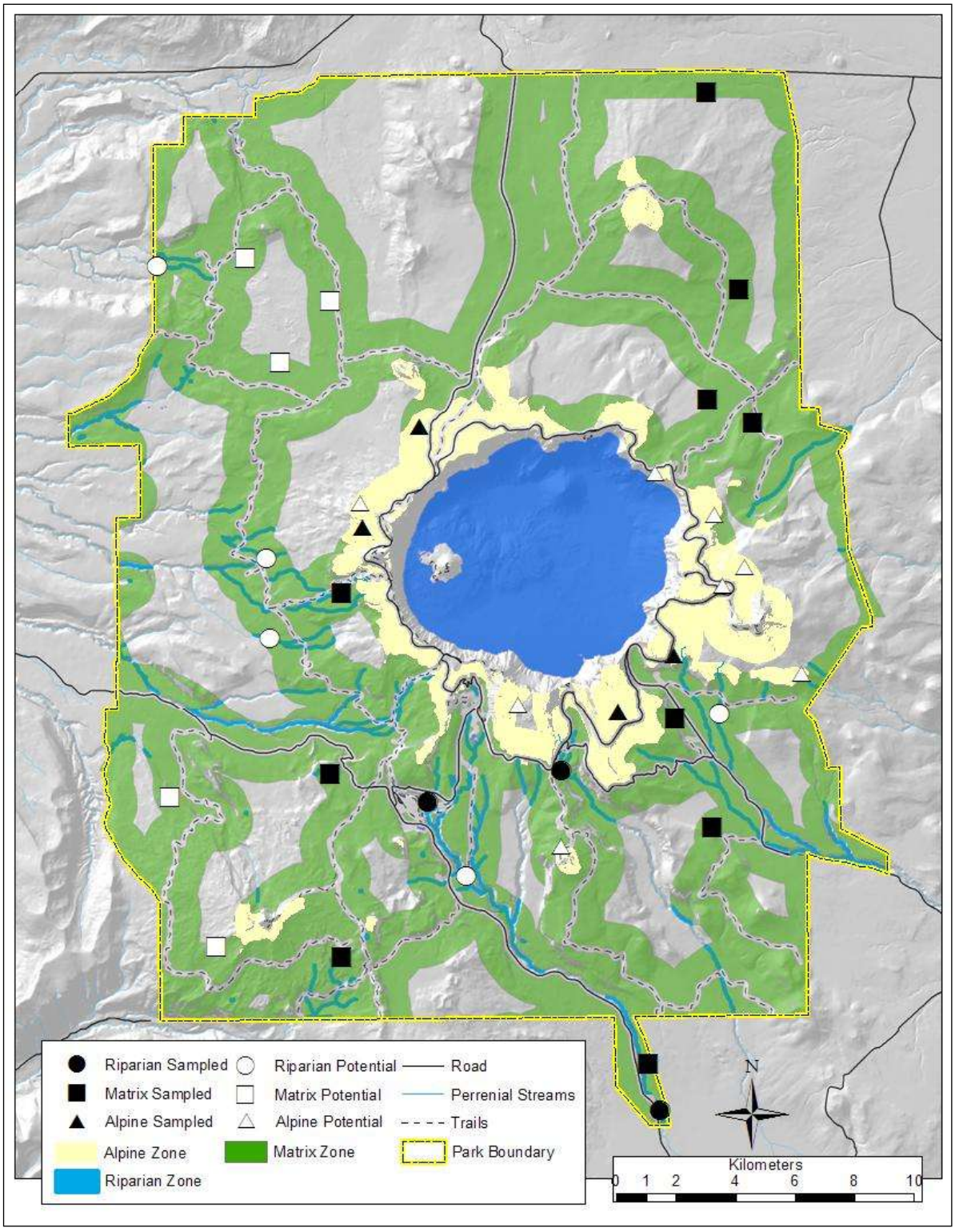

Figure 1. Sampling domains and potential sites for sampling during the vegetation Pilot Study at Crater Lake.

Field Sampling

In 2008, 17 of the 35 sites (4 alpine, 10 matrix, and 3 riparian) were sampled (Figure 1). A 20 x 50 m plot was used for matrix and alpine sites (Figure 2); a 10 x100 m plot was used for riparian sites (Figure 3). The elongated riparian plots were used to avoid going too far into the upland habitat type. Each plot consisted of ten 10 x 10 m modules, four of which were sampled intensively for cover, and seedling and sapling data.

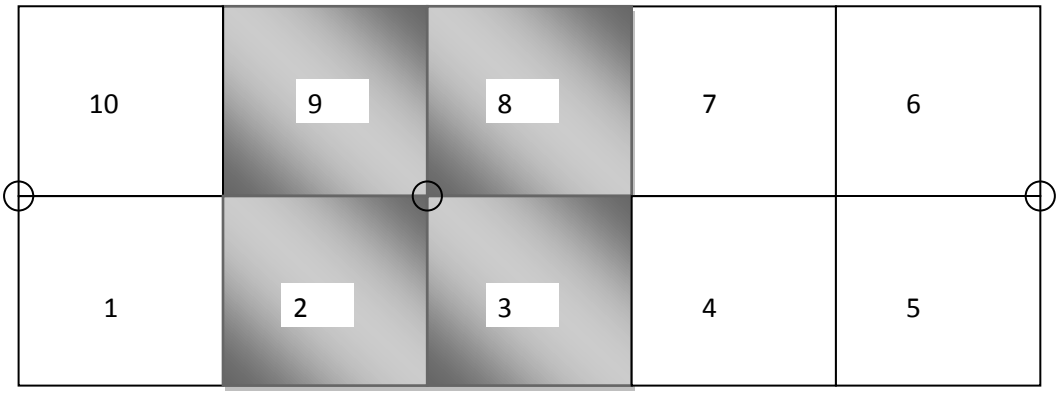

Figure 2. The 20 x 50 m matrix and alpine site layout. Each numbered square is 10 x 10 m. Shaded squares are the 4 intensive modules.

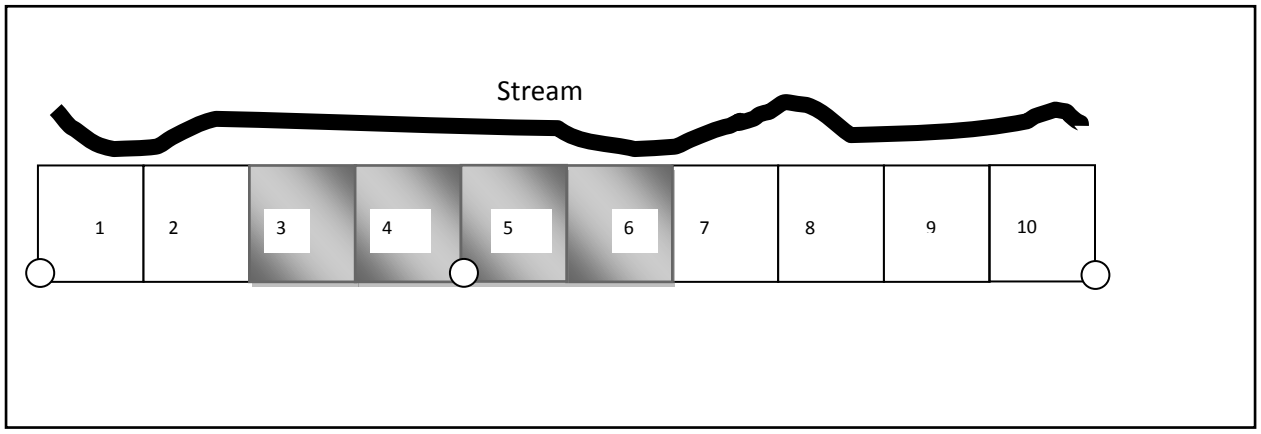

Figure 3. Ten x 100 m riparian site layout. Each numbered square is 10 x10m. Shaded squares are the 4 intensive modules.

Standard operating procedures 6-9 of the vegetation protocol (Odion et al. 2009), provide details on the collection in each plot of measurements of the following parameters:

1. Slope
2. Aspect
3. Elevation
4. Microtopography
5. Macrotopography
6. Vascular plant cover by species (three height strata)

7. Ground cover
8. Tree seedlings
9. Tree saplings by size class
10. Small trees by size class
11. Live trees (dbh, canopy position and condition)
12. Dead trees (dbh, decay class)
13. Fine wood (<7.6 cm diameter)
14. Coarse wood (>7.6 cm in diameter, size and decay class)
15. Litter and Duff: (depth/thickness)

Data Management, Analysis and Presentation

All data management followed the procedures outlined in Standard Operating Procedure 12 of the Vegetation Monitoring Protocol. General data summaries were conducted to provide measures of central tendency (mean, median) and variance (range, standard deviation) for each parameter. Select data are presented in tabular form, and where suitable, user-friendly graphical format to aid in the visualization of data distribution or geographic variation across the sampling frame. A procedure for producing bubble maps was created for use in the future. Depending on data collected in future monitoring, annual reports may show different parameters, but will use the same type of tables and illustrations.

Results

Here we summarize selected data most relevant to our pilot study and monitoring objectives. Appendix 1 provides a more comprehensive summary of the environmental data collected at each site.

Time to Complete Sampling

Travel time to and from sites ranged from 15min to 2hrs, depending upon the distance from a suitable parking area and the terrain encountered. The time required to complete the plot measurements was also highly variable and depended on vegetation density and within-site diversity. Table 1 shows time variation for completing plot parameters, while Figure 4 summarizes the completion time data. The mean completion time was 4.6 hours (range 1.5-8.5 hours). These data indicate that, notwithstanding a few plots that took extra long to get to and sample, a rate of at least one plot per scheduled field day appears feasible in Crater Lake over the course of a field season. With good logistical planning it may be possible to complete more than one plot per day, particularly in the alpine sampling frame.

Table 1. Time to complete plot measurements and the order they were completed.

Sampling parameter	Time to complete measurements
Plot Setup, photographs, measure environmental variables	30 min- 2 hours
Subplot Sampling (cover values, small tree, saplings and seedlings)	10 min-1 hour 45 min x4 (numbers are for one of 4 intensive modules)
Overstory Sampling (tree measures)	0-2 hours 30 min
Dead and down wood and litter	0-1 hour
Canopy cover and searching for new species in the 0.1ha site	0-45 min

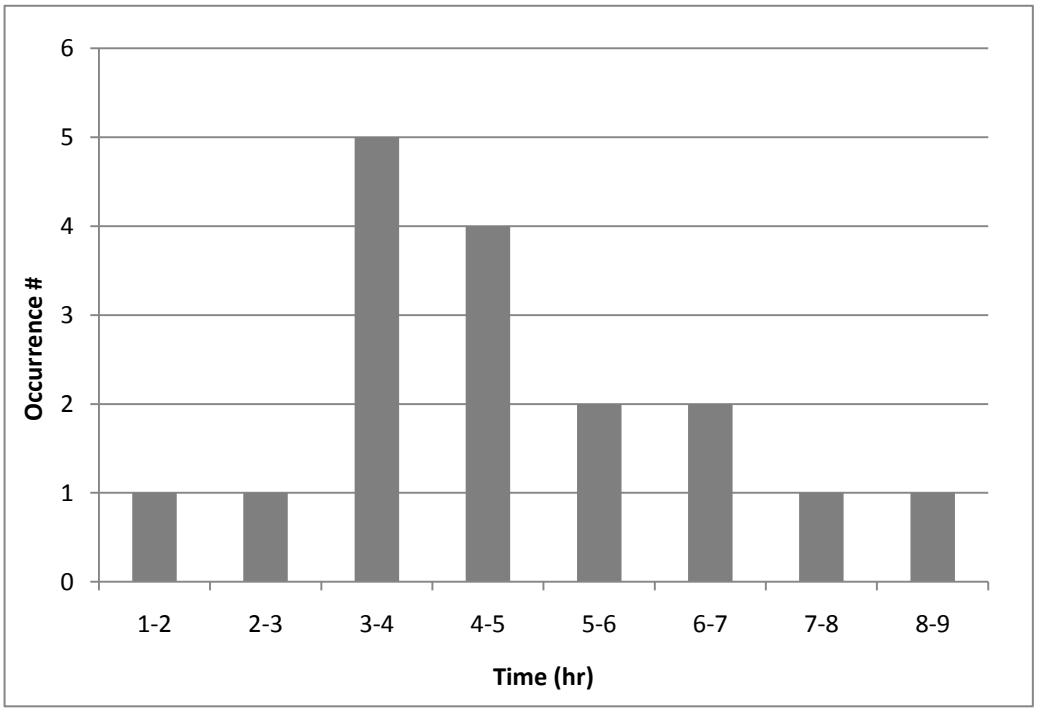

Figure 4. Histogram of the time required to complete plots during the pilot study.

Vegetation Composition

The most frequently occurring understory species by sampling frame are shown in Table 2. Four less common species were encountered that were not found in NPSpecies and were added (*Aster campestris, Ericameria greenii, Eriogonum pyrolofolium, and Salix geyeriana*). However, these were listed in Zika's 2003 Crater Lake flora. Overstory species and their relative basal areas are shown in Figure 5.

Table 2. Understory species listed which occur in at least 2 matrix, and 3 alpine and riparian sites. Actual annual reports will contain a complete list of species encountered as an appendix.

Herbs	Alpine	Matrix	Riparian	**Herbs**	Alpine	Matrix	Riparian
Aconitum columbianum			x	*Senecio triangularis*			x
Allotropa virgata		x		**Graminoides**	Alpine	Matrix	Riparian
Angelica genuflexa			x	*Achnatherum occidentale*	x	x	
Arabis platysperma	x			*Calamagrostis canadensis*			x
Arenaria pumicola	x			*Carex inops ssp. inops*		x	
Chimaphila menziesii		x		*Carex rossii*		x	
Chimaphila umbellata		x		*Elymus elymoides*	x	x	
Cistanthe umbellata	x			*Juncus parryi*		x	
Equisetum arvense			x	*Luzula hitchcockii*		x	
Eriogonum pyrolifolium	x			*Poa wheeleri*			x
Hieracium albiflorum		x		**Shrubs**	Alpine	Matrix	Riparian
Kelloggia galioides		x		*Eriogonum umbellatum*	x		
Lupinus andersonii	x	x		*Arctostaphylos nevadensis*	x		
Lupinus polyphyllus			x	*Arctostaphylos patula*		x	
Polygonum newberryi	x			*Ribes lacustre*		x	
Pyrola picta		x		*Salix scouleriana*		x	
Pyrola secunda		x	x	*Vaccinium scoparium*		x	

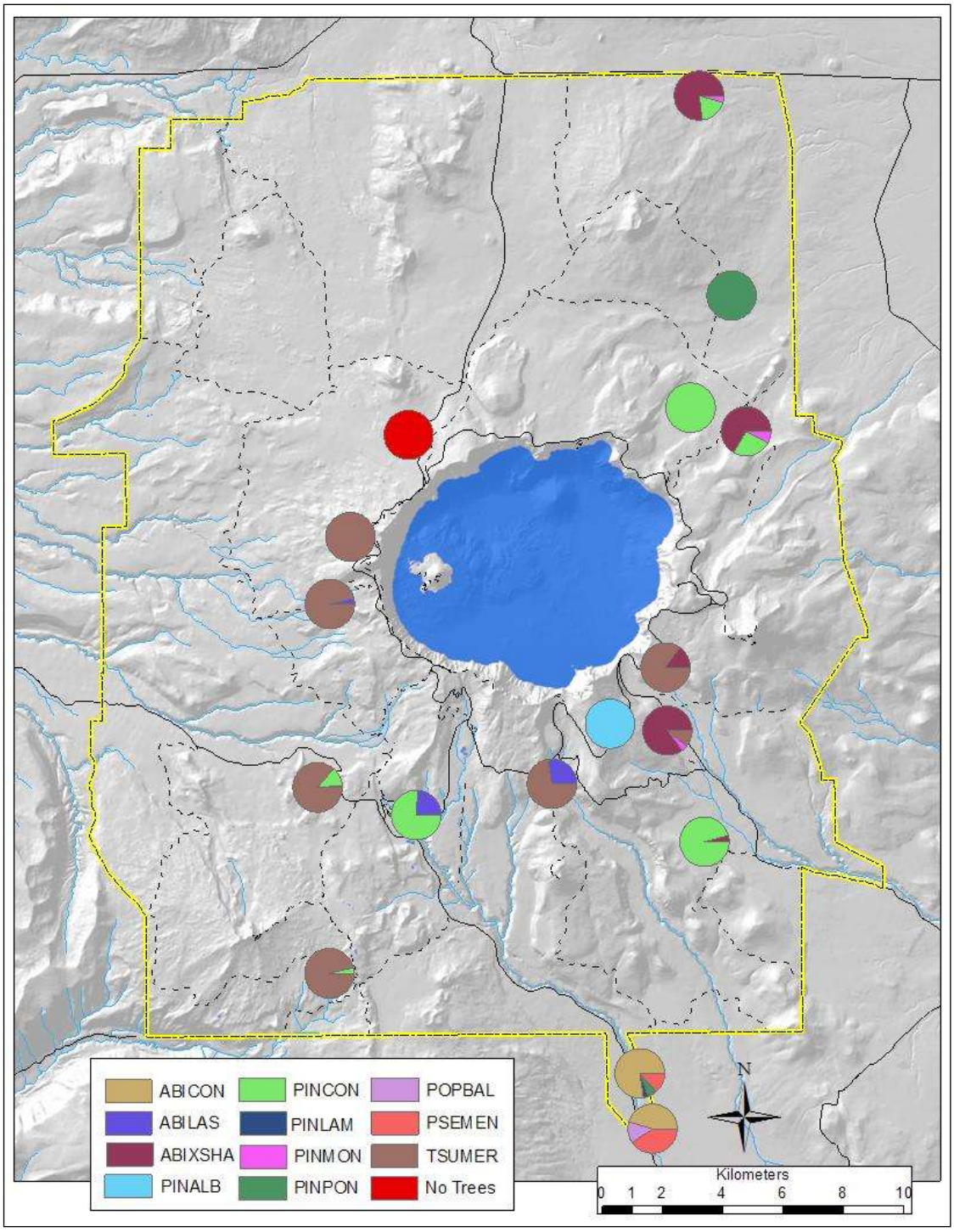

Figure 5. Individual tree species composition of the total basal area for each site. **NOTE**: the total basal area of each plot is not represented in this figure; refer to figure 8 for total basal area data. ABICON= *Abies concolor*; ABILAS= *A. lasiocarpa*; ABIXSHA= *A.* X *shastensis*; PINALB= *Pinus albicaulis*; PINCON= *P. contorta*; PINLAM= *P. lambertiana*; PINMON= *P. monticola*; PINPON= *P. ponderosa*; POPBAL= *Populus balsamifera*; PSEMEN= *Pseudotsuga menziesii*; TSUMER *Tsuga mertensiana.*

Mountain hemlock (*Tsuga mertensiana*) was the most dominant tree, followed by lodgepole pine (*Pinus contorta*). Other species were not widespread, but were locally dominant, such as white fir (*Abies concolor*) and whitebark pine (*P. albicaulis*), and Douglas-fir (*Pseudotsuga menzesii*). The riparian, alpine and matrix sampling frames had mean species richness of 62, 16 and 13 species per plot, respectively. Spatial patterns of richness are shown in Figure 6. Only one site contained a nonnative species, dandelion (*Taraxacum officinale*).

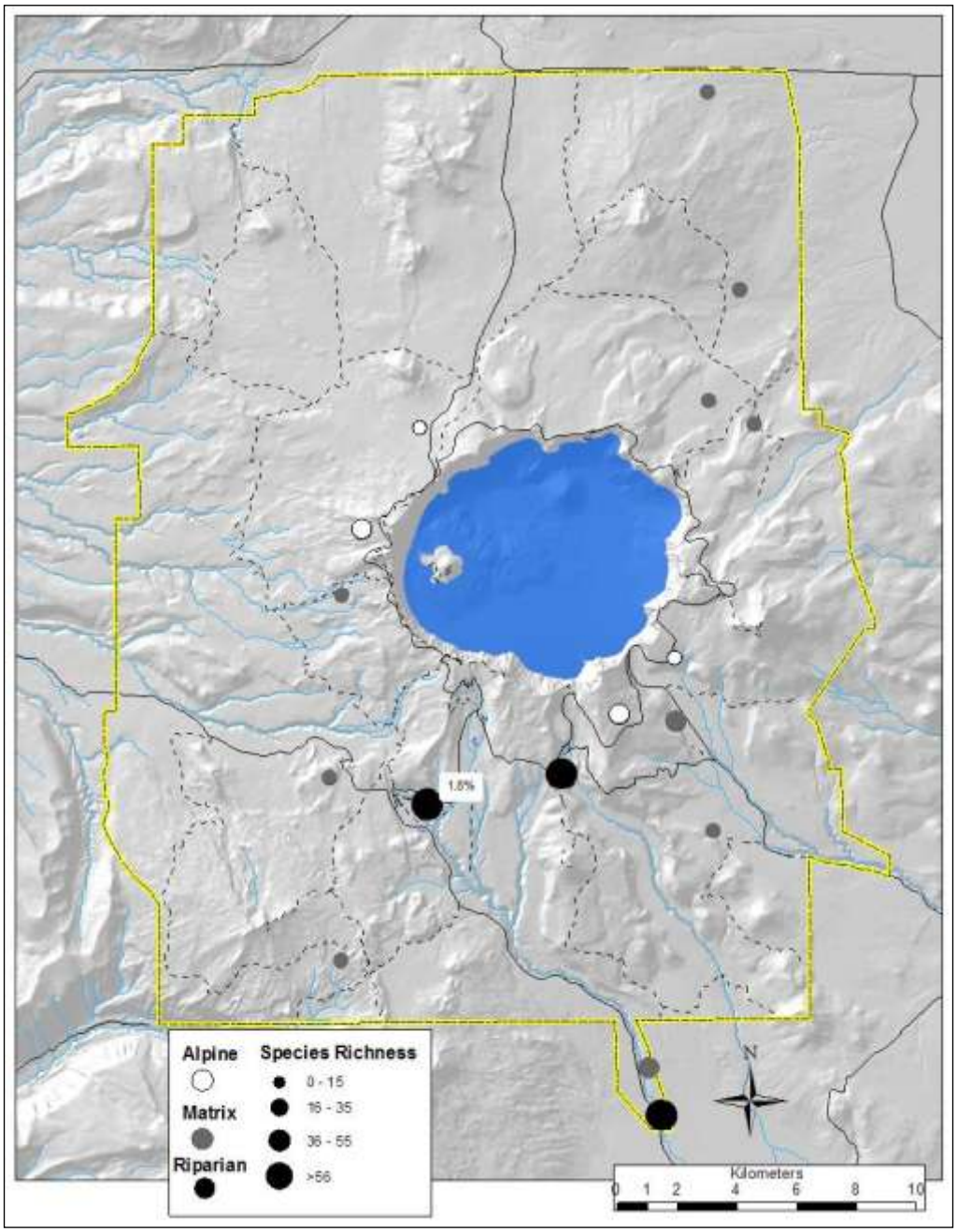

Figure 6. Site species richness from each sampling frame displayed by bubble size. Label shows percentage of species that are nonnative. Sites without a label do not have any nonnative species.

Vegetation Structure

Percent cover by stratum varied across the park (Fig. 7). Riparian sites had the highest cover for the 0-.5 m and >0.5-4.99 m strata, 56% and 47% respectively, but the lowest cover for the >5m stratum, 14%. Alpine sites had the lowest percent cover for the 0-.5 m and >0.5-4.99 m strata, 12% and 1%, respectively. Matrix sites had the highest cover for >5m stratum, 23%. Average total cover ranged from lowest in alpine (28%), to intermediate in matrix (55%), and highest in the riparian stratum (118%).

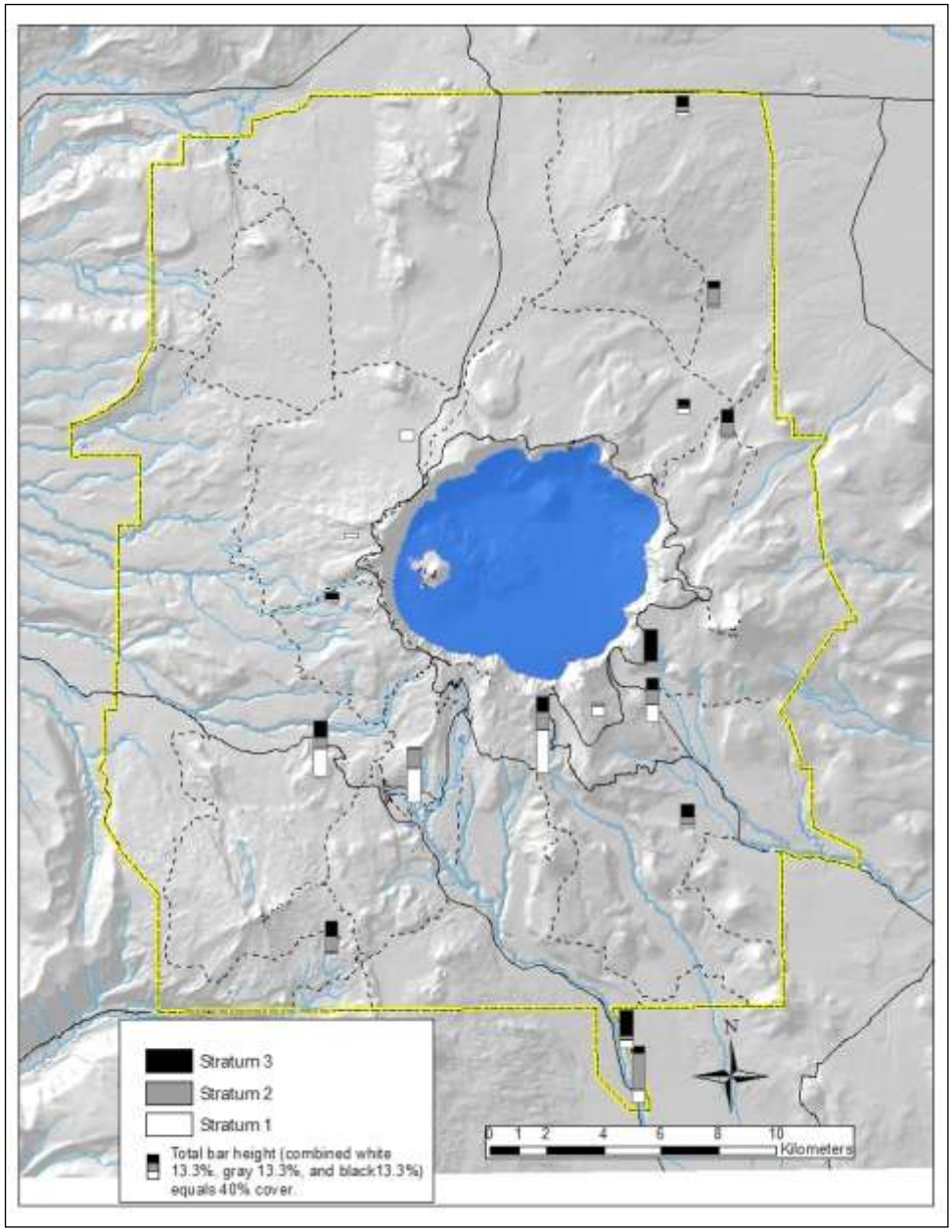

Figure 7. Vegetation cover percentages for each site by height strata Stratum 1= 0-.5m, stratum 2=>.5-4.99m, stratum 3= >5m.

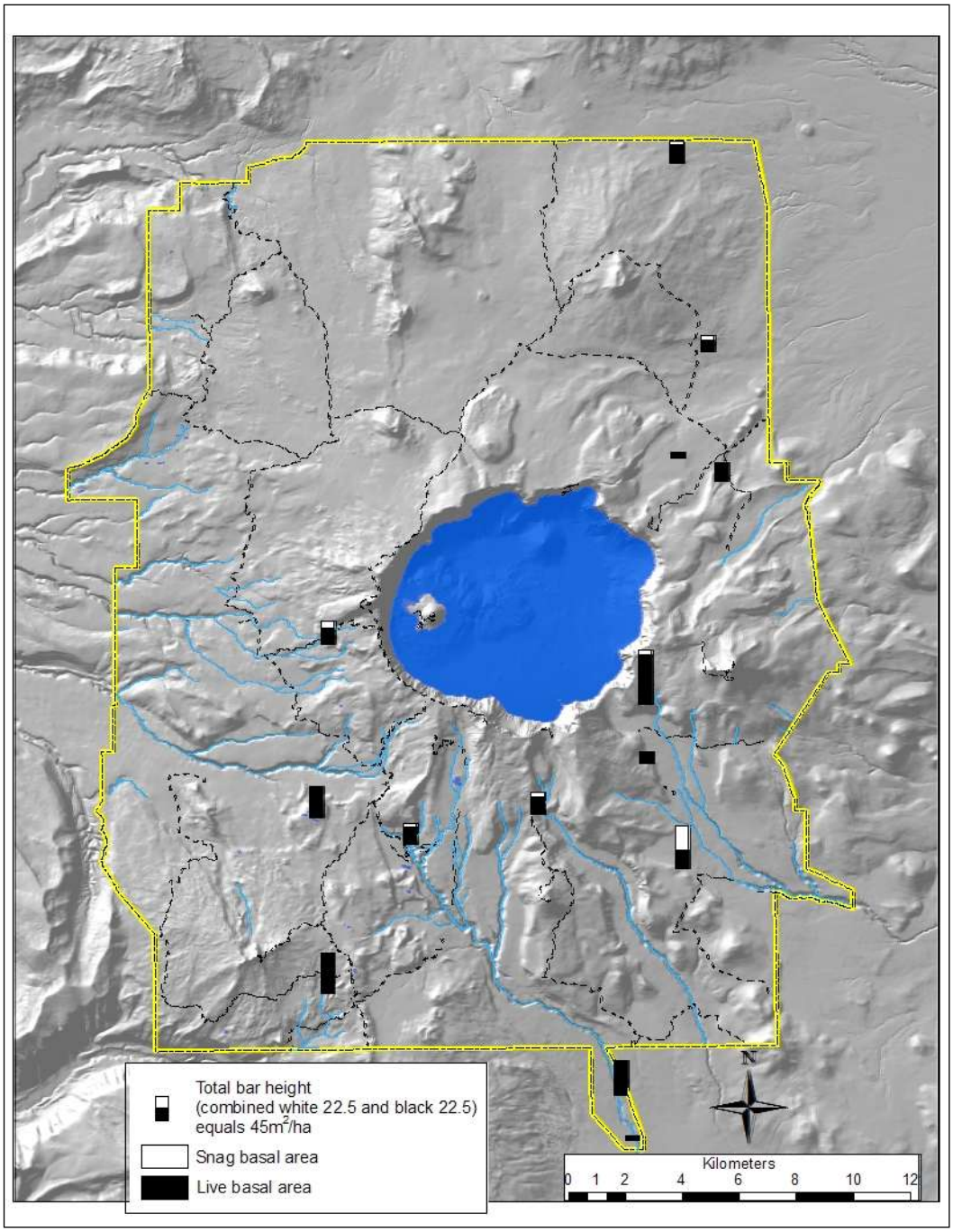

Figure 8. Live and dead tree basal area for each site. Sites with < 8m^2/ha, combined live and dead, basal area are excluded from this figure.

Live and dead tree basal area by site are illustrated in Figure 8 and summarized by sampling frame in Table 4. Basal area was highly variable and lowest in riparian areas and highest in matrix areas. Several plots lacked dead trees, while one plot dominated by mountain hemlock had mostly dead trees as a result of the Bybee Fire in 2006. Mean canopy base heights varied little between sampling frames (Table 4).

Table 4. Mean of dead and live tree parameters. Standard errors are shown in parenthesis.

	Dead		Live			
Sampling Frame	**Basal Area (m^2/ha)**	**stems/ha**	**Basal Area (m^2/ha)**	**stems/ha**	**Height to Crown (m)**	**Max.Tree Height (m)**
Alpine	2.2 (2.2)	40 (40)	24.6 (21.6)	153 (111)	8.6 (0.8)	25.1 (2.4)
Matrix	7.3 (4.2)	70 (30)	37.1 (6.2)	370 (65)	6.6 (0.3)	23.1 (0.8)
Riparian	5.6 (3.2)	20 (10)	23.5 (7.7)	137 (30)	7.7 (1.3)	27.1 (2.2)

Table 5 shows the 1, 10, 100 and 1000 hr time lag fuels. These were highest in the matrix and lowest in the alpine sampling frame, except 1000 hr rotten wood, which was highest in the alpine sampling frame. One alpine site had a total of 177 tons per acre, due to the fact that one down whitebark pine log was mismeasured. We determined this error retrospectively. The occurrence of this measurement error lead to a change in the protocol; now each data sheet will be reviewed as soon as it is completed. In the pilot study, all data sheets were reviewed at the end of sampling a site.

Table 5. Summary of woody debris time lag classes reported in tons per acre. Standard errors are shown in parentheses. S = Sound, R = Rotten.

Sampling Frame	**1 hr fuel**	**10 hr fuel**	**100 hr fuel**	**1000 hr S fuel**	**1000 hr R fuel**
Alpine	0.08 (0.07)	0.29 (0.20)	0.42 (0.36)	2.5 (2.5)	66 (41)
Matrix	0.52 (0.18)	0.89 (0.16)	1.8 (.27)	17 (4.6)	17 (6.4)
Riparian	0.04 (0.03)	0.3 (0.18)	1.8 (1.1)	11 (10)	34 (26)

Ground parameters are summarized in Table 6. The matrix sampling frame had the deepest litter and duff layers, while the alpine sampling frame had the shallowest. Mean bare soil in the alpine sampling frame was over ten times higher than the matrix or riparian frames. Mean bryophyte cover was greatest in the riparian sampling frame.

Table 6. Summary of mean and standard error of ground parameters. Standard errors are shown in parentheses.

Sampling Frame	Thickness/depth (mm)		Cover (%)			
	Litter	Duff	Fine wood /litter	Coarse Wood	Bryophyte	Bare Soil
Alpine	5.0 (2.6)	6.0 (4.8)	22.5 (20.8)	4.3 (3.0)	0.0 (0)	57.0 (19.8)
Martix	14.9 (1.6)	20.5(3.6)	68.4 (5.6)	8.4 (1.6)	0.1 (0.1)	4.2 (3.1)
Riparian	7.7 (4.1)	13.3(6.8)	11.3 (5.6)	6.0 (3.5)	6.3 (5.8)	2.7 (1.8)

Vegetation Function

The matrix sampling frame had the highest numbers of seedlings saplings and small trees (Table 7). The alpine sampling frame had the lowest densities, with zero small trees in all pole classes.

Table 7. Summary of densities/ha of seedling, saplings, and small trees. Standard errors are shown in parenthesis.

Sampling Frame	Seedlings <20cm tall	Saplings 20cm tall-1.4m tall	Small trees 1.4m tall-5cm DBH	Small trees >5 - 10cm DBH	Small trees 10 - 15cm DBH
Alpine	1750 (1668)	0 (0)	0 (0)	0 (0)	0 (0)
Matrix	4300 (1927)	2050 (595)	338 (103)	138 (43)	1085 (368)
Riparian	2250 (1181)	1750 (764)	50 (14)	8 (8)	383 (79)

Changes to Protocol

As a result of the pilot study a number of possible improvements to the protocol were revealed. These were evaluated with Klamath Network staff, and the following changes were made:

- **Height strata—**changed from three (<0.5 m, 0.5-4.99 m, and >5 m) to four (<0.75 m, 0.75-2.5 m, >2.5-5 m, and >5 m.
- **Shrub height—**added an average shrub height measurement for each of the 4 intensive modules. We did this to quantify potential ladder fuels in each intensive module.
- **Incidental photo metadata sheet—**added an incidental photo metadata sheet to the protocol. This will allow easier differentiation between site specific and incidental photographs.
- **Water to ground cover—**added water as a category for ground cover. This was needed especially for some riparian sites**.**
- **Double check data sheets right after sampling parameters—**In the pilot study, data sheets were double checked in the field once all field sampling was completed. One important error could have been prevented by double checking the data sheet sooner.

- **Allow plots exceeding 30 degrees slope to be sampled—** This can be at the crews discretion depending on whether the plot can be sampled safely and whether it is on a three or 30 year revisit cycle. There is greater concern for trampling damage in plots that are on a 3-year revisit cycle.

Discussion

The pilot study demonstrated the feasibility of implementing the vegetation protocol and led to a number of suggested changes. Future annual reports will discuss the status of vegetation sampled in a given year and any outstanding trends. The likely significance and cause of trends will be described based on pertinent literature. No discussion about vegetation sampled is provided here because the sample size was too limited to draw significant inferences.

Appendix 1. Site data and environmental parameters collected during the Crater Lake vegetation monitoring pilot study.

Site	Sampling Frame	Easting	Northing	Date Monumented	Macro Position	Slope Shape	Average Slope (Deg)	Average Aspect	Elevation (m)
Site-003	Alpine	568703	4759038	8/21/2008	MACPOS 2	Straight	3	180	2061
Site-004	Alpine	575389	4749419	8/5/2008	MACPOS 1	Straight/convex	16	173	2292
Site-009	Alpine	566771	4755641	8/25/2008	MACPOS 2	Straight	19	250	2184
Site-010	Alpine	577235	4751300	8/14/2008	MACPOS 2	Concave	23	45	2144
Site-013	Matrix	578390	4759947	8/19/2008	MACPOS 3	Straight	0	0	1800
Site-014	Matrix	566065	4741113	8/28/2008	MACPOS 3	Concave/straight	0	0	1890
Site-017	Matrix	579910	4759160	8/20/2008	MACPOS 3	Straight	21	100	1760
Site-018	Matrix	565679	4747304	8/6/2008	MACPOS 2	Straight	0	0	1920
Site-019	Matrix	576379	4737535	9/2/2008	MACPOS 3	Straight	0	53	1410
Site-021	Matrix	578345	4770335	8/18/2008	MACPOS 3	Straight	4	30	1699
Site-022	Matrix	566087	4753406	8/21/2008	MACPOS 3	Concave	17	347	1948
Site-023	Matrix	578529	4745493	8/26/2008	MACPOS 3	Undulating	9	87	1752
Site-025	Matrix	579425	4763682	8/19/2008	MACPOS 3	Straight	0	0	1632
Site-027	Matrix	577293	4749192	8/13/2008	MACPOS 3	Straight	45	10	1917
Site-028	Riparian	576940	4734615	8/26/2008	MACPOS 4	Straight	0	0	1340
Site-032	Riparian	573462	4747425	8/12/2008	MACPOS 4/5	Concave	30	83	1895
Site-034	Riparian	568954	4746380	8/7/2008	MACPOS 5	Straight/concave	8	60	1739